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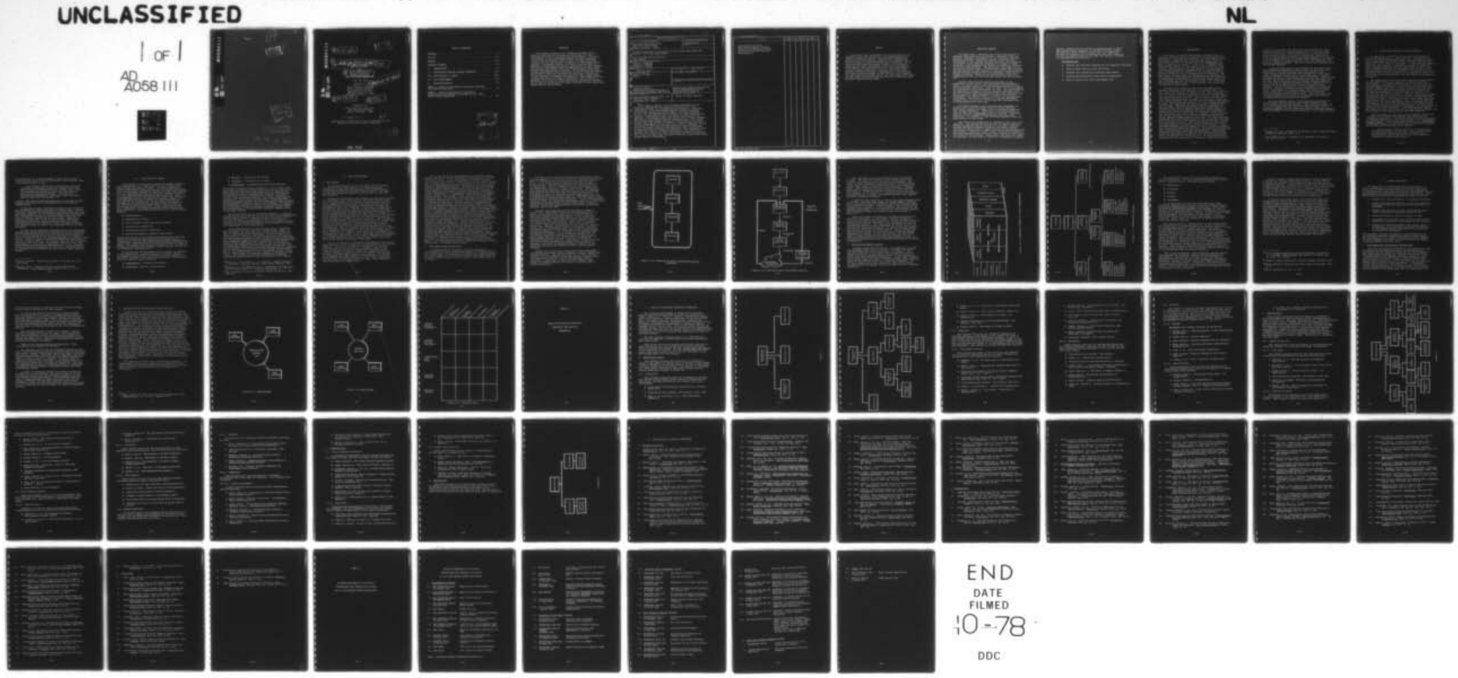

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IN-DEPTH ASSESSMENT OF THE STATUS OF DISTRIBUTED DATA BASES AND POTENTIAL U.S. NAVY REQUIREMENTS. (U)

BY

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ABSTRACT

This report consists of an "In-depth Assessment of the Status of Distributed Data Bases and Potential U.S. Navy Requirements" with two accompanying bibliographies. Following a discussion of the distributed computer systems technology and its very considerable significance, the report proceeds to point out the implications of adoption of this decentralized approach. Proceeding further, the report concludes that the question of distributed processing applications to Navy strategic and tactical requirements must be approached from a more fundamental basis than system conversion. We recommend an analysis of Navy requirements from a functional frame of reference, during the course of which the functions and activities necessary to fulfill the Navy's missions and objectives under various modes of operation must be studied and specified. When completed, this analysis will serve as a basis from which to move directly to decisions as to areas for which distributed systems are appropriate as well as those areas for which retention of more centralized system control is desirable.

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PREFACE

Shared and valid information is essential whenever one wishes to reduce the uncertainty, risk and potential cost involved in decision making. Data Solutions Corporation believes that this axiom is especially true regarding the Navy's interest in distributed data base technology. We are quite concerned with the present tendency for the supply caused by the quick development of data base technology to drive demand. DSC believes that such a situation unnecessarily increases uncertainty, risk and cost in the Navy Manager's decision function. Consequently we have targeted our report and bibliography so that the generalist managers can "get ahead of the power curve" and better demand the supply of distributed data base technology that best fits their real missions, objectives and needs.

EXECUTIVE SUMMARY

In recent years a radically new concept and approach to automatic data processing has emerged. Basically, this new approach envisages a de-emphasis of and a departure from the currently prevalent centralized computer operations and a replacement of such systems by decentralization and delegation of function to the component elements of a system of lesser computers. Such decentralized systems are frequently referred to as distributed systems. The purposes of this paper are to analyze the current status of distributed systems and to assess the implications of such systems as a prelude to addressing the central problem created by this new technology, which can be stated as follows: "What are the implications of this new technology for the U.S. Navy and what should the Navy do about it?"

We have selected three specific objectives in the preparation of this report and accompanying bibliographies, First, our target group is Navy management personnel who have limited computer background. Both the report and bibliographies are written with this consideration in mind. Our bibliographies are especially intended to provide management personnel with the basic issues regarding distributed data base technology and with a source of ready reference on relevant instructions. Furthermore, the material cited is in basic and understandable terminology. Thus we are attempting to provide management personnel with a useful key to the technical literature that is being generated at this time.

Our second objective is to persuade Navy management to abandon their localized single problem solution approach. This report presents the reader with an alternative approach that is more systematic. Specifically our recommendation is that the Navy use a functional frame of reference in deciding whether or not to adapt to a distributed data base (DDB) technology. An analysis of this functional approach forms the major portion of this study.

This functional perspective is intended to serve our third objective. DSC consultants believe that a dialogue regarding software management must be initiated in the Navy, bringing together Key Navy management personnel and general systems specialists working under a common taxonomy of problem definition and solution. Section V of this report, "Solution Strategies," identifies precisely what steps we believe should be taken during the course of this dialogue. Having built the functional frame of reference, the next step of selection of appropriate computer

systems, ranging from centralized to decentralized, to serve each organizational component is rendered relatively simple. The resultant total system structure will be a harmonious blending of component system alternatives each best suited to its own requirements while at the same time forming a coherent and workable part of the whole.

Recommendations:

1. Identify for each Navy organization its essential functions

2. Dissect these functions into activities

3. Identify the information processing requirements

4. Examine distributed data base network alternatives

5. Draw up training and skill development plan

I. INTRODUCTION

"The rate of growth of the computer industry since its embryonic stages in the late 1940's has been nothing short of phenomenal." Thus Captain Jan Prokop, SC, USN, characterized the growth of computer usage over the past thirty years in his opening article for the excellent book Computers in the Navy, of which he is editor.[1] Indeed, it is probable that the computer industry is the fastest growing industry in the country. During this period, the computer has gone through several major changes or transformations in its development. Each transformation has resulted in the emergence of what is generally referred to as a new generation of computers. The most recent of these major transformations, the emergence of the smaller and less expensive computers which have permitted a considerable decentralization of computer usage, may be the most important and most far-reaching of all. It is this most recent transformation, and its implications, that constitute the purpose of this report.

The very first computers were large and complicated machines dedicated to one application or purpose only. They were also very expensive--so expensive that several prospective users often got together to acquire one for their mutual use. This, of course, led to considerable conflict as to what purpose the computer would be used for. This situation led directly into the second generation of computers, which were larger and more complex machines that could be used for several applications at once. This concurrent utilization, called multiprogramming, required very complicated operating systems to schedule the various tasks. During this period we saw the development of the specialized data processing departments, which grew up in order to cope with the problems inherent in multiprogramming operations. The third generation of computers, which came in the late 1960's, was really only an expansion or elaboration of the second, featuring larger and more powerful machines and larger and more complex support structures. The data processing departments grew and became staffed by specialists who each knew his or her own role in the overall process but who were removed from the overall picture. This period marked the high point in the centralization of computer growth and development: larger, centrally located computers handled by large central departments. This system was complex and top-heavy, overloaded with specialized jobs, and production costs kept getting higher. Furthermore, management was completely removed from the processing of information and had minimum contact with its processing department, which was regarded as a necessary evil. As cost-effectiveness deteriorated, the acquisition of additional computers was often

regarded as a panacea, but this led to the problem that these computers would be programmed differently and would not relate to existing programs. This situation led to a great push for standardization, so that all one's computerized assets could relate to one another, although this standardization often proved to be extremely difficult and indeed almost impossible in actual practice without the radical alteration or even abandonment of existing computer programs. The entire system was becoming almost intolerably unwieldy.

It was into this kind of environment that the smaller and less expensive minicomputers came on stage in the early 1970's. Offspring of the space program, these new computers were revolutionary because they were now available to a much larger number of potential users and in larger quantities. However, although the cost of the hardware was now going down (between 1965 and 1975 the relative cost of hardware declined from about 75% to about 25% of the total cost for computer systems support),[2] the total cost of operating computer systems continued to go up because of the tremendous need for more programming--more software--for all the computers, and for people to develop the software. Software costs are largely determined by personnel costs. The demand for software people with expertise became almost desperate, and many poorly trained and marginally competent personnel sold their services. This, of course, led to badly designed and ineffective programming, which further exacerbated existing problems and tensions.

The minicomputer was one of two innovations necessary to permit escape from the massive centralized complexity that the computerized world was becoming. What was still needed was a way of breaking down the single centralized system into a system of systems, so that complexity could be gradually reduced. With the advent of the switching capability, this became possible.

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[1] Prokop, Jan, Ed., "Computers in the Navy," Naval Institute Press, Annapolis, Maryland, 1976, p. 8.

[2] Haak, RADM Frank S., "Brainwave vs. Hardware," in Prokop, op. cit., p. 10.

II. DISTRIBUTED COMPUTER SYSTEMS TECHNOLOGY

At some point in the life of any system it becomes too large to be sustained by a single control. Responsibilities must be delegated, and tasks divided. When this happens, each task becomes less complicated, easier to focus upon, and nine times out of ten, easier to deal with. In the world of computers, this meant the creation of a network or series of computers, each performing component tasks or steps that are part of the whole, connected together by a communications system so that the components can "talk" to each other. As we have seen, the concept of the "system of computers" could become a reality with the advent of two developments: the minicomputer and switching systems.[3]

The significance of the now fairly widespread availability of the relatively low cost system of computers is almost incalculable. It permits the correction of virtually all of the weaknesses and vulnerabilities that had come to typify the typical computer operation. For one, the sheer physical limitations of the great central computer could be overcome, by having several computers working together do the job of one. At least as significant is the fact that the complexity of the software can now be overcome: a number of relatively simple programs can take the place of a single massive hierarchically structured program. This simplification of programs also means fewer errors, and less "debugging" time. The fourth important advantage is that the whole operation does not depend upon one key computer; if one of the minicomputers in the system breaks down, it can readily be replaced or bypassed. The new systems of computers have every advantage: less cumbersome and complex, much easier to work with, requires less complicated software, can be serviced by fewer people and is much less expensive.

Many new terms are being used in the computer industry as a result of the present push towards decentralization of information processing. A currently popular term for the system of computers that we have been talking about is the Distributed Computer System. Such a system was defined at the Distributed Processing Workshop at Brown University (August 1977) sponsored by the Office of Naval Research as follows:

> "A Distributed Computer System is a collection of processing elements (of any size: micro to maxi) which are logically and physically interconnected with a decentralized system-wide control for the cooperative execution of single applications."

This definition is rendered somewhat clearer by providing a further definition of a centralized system, and therefore, what a distributed system is not:

> "In a totally centralized configuration, all three functions--information processing, network processing, and data base processing--exist at a single site. This site provides all resources required by the terminal users in the surrounding network. In a totally distributed configuration, each of the three functions exist in more than one location."[4/]

In short, what the distributed system does is to break up both hardware and software into subassemblies and link them by communications.

On the face of them, distributed systems are so attractive that consumers are rushing pell-mell to acquire them. Initial reticence, occasioned by apprehensions that going this new route would mean junking a lot of existing computers and programs, has been largely overcome by the realization that you do not junk your old computer, you merely add some simple inexpensive computers to work with it and lessen its load. Furthermore, although certainly most existing programs had to be either drastically modified or abandoned, their replacement programs were simpler, easier to build, less confusing, and not all that expensive.

In spite of the undeniable attractiveness of the distributed systems, Data Solutions has some distinct reservations about the across-the-board desirability of such systems in all situations. We are nervous because we are aware of the truth that technological innovation serves as a forcing function in a gadget-oriented society: there is great pressure to be modern and up-to-date, to take on the latest fashion. We recognize that the new distributed technology is of very great significance, and yet we fear that uncoordinated acquisition and implementation of this technology could have adverse consequences for the Navy. Our reservations are discussed in the following section entitled "Implications of Change."

3/ Hopper, Grace M., "David and Goliath," in Prokop, op. cit., pp. 64-65.

4/ Becker, Hal B., "Network Security in Distributed Data Processing," Data Communications, August 1977, pp. 33-39.

III. IMPLICATIONS OF CHANGE

Early success in distributed systems by already decentralized organizations will tempt others to mimic without fully understanding the impact of change. For those information systems which become decentralized with the oncoming technology shift to distributed information systems, the host organizations will feel increasing pressure to shift from centralized control to a more decentralized, autonomous control process. Each organizational entity could increasingly acquire the capability to respond more quickly to external or internal stimuli. If this increase in response time was not compatible with the remainder of the organization, it could prove detrimental to the stability, missions and objectives of other entities as well as the overall organization. Since information is the major component of the control mechanism of the organization, decentralization or distribution can bring with it the following dangers:

- Misinformation
- Duplication of effort
- Power struggles concerning goal attainment
- Dysfunctional competition
- Misinterpretation of perspective
- Security compromise, sabotage, embezzlement.

Centralized control of the organization becomes more difficult because of the various level and function perspectives on information created by distributed organizational problem-solving capabilities. Organizational structure and process will have to change. New architectures would be required as well as enabling structures, processes and resources to move from the "as is" to the "should be" configuration.[5]

We believe that the management goal of control is essential in any organization, and particularly in the Navy. However, the <u>degree</u> of control that is necessary, or even advisable, in different operational areas may vary considerably. We conceptualize five general types of control:

- <u>Technological</u>: hardware and software
- <u>Structural</u>: policies and procedures

- Resource: information and funding
- Personnel: management and training
- Performance: standards and productivity measures

The degree of centralization of control in each of these five areas that is necessary and desirable will vary in each organization and will also vary from organization to organization. What degree of control is deemed most efficient and effective in each control area is determined by a number of decision factors, i.e., situation, function, time frame, organizational objectives.[6] All of these factors must be considered when management examines each of the five areas listed above in which varying degrees of control, ranging from complete centralization, the monolithic pyramidal structure, at one extreme, to complete decentralization, in which each basic component element makes its own decisions for itself without any upper echelon review, at the other extreme.

The basic purpose of any information system is to get the information that is needed by any and all users in an organization (whether they be human or mechanical users) to get his or her (or its) job done in a reasonable period of time. The real significance of the new technology is that more options are now available so that information systems can be tailored to satisfy the requirements of the organization.

Every technology has its own inherent logic. Therefore, new technology over time will have a revolutionary impact in that it exposes the user slowly but surely to an entirely new logic of dealing with the environment. Logics of coping in a centralized or a decentralized information system are different. External pressure, however, forces innovation of new technologies even though the organization is not capable of implementing them. These pressures should and can be dealt with in an orderly manner if the organization will begin to look at the missions and objectives together with the constraints and develop a set of requirements under which information systems will be configured. This is basically a restatement of the top down design philosophy.[7] The implementation of such a philosophy is made easier, but not solved, with the increasing options of hardware configuration. The problem of designing and developing enabling information systems within a given organization still remains.

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[5] Burns, E. J. and Proctor, J. H., "Sistemi e Amministrazione," in Paradigmi a Societa, Milano, Franco Angeli Editore, 1976.

[6] Proctor, J. H. and Lassiter, W. E., "Prediction of Young U.S. Naval Officer Retention," Personnel Psychology, Vol. 29. no. 4.

[7] Beer, Stafford, "Brain of the Firm," Herder and Herder, 1972, New York.

IV. NAVY REQUIREMENTS

A. The Problem

In the previous sections of this report we have looked in a general way at some matters that ought to be given consideration concerning the advantages and disadvantages of introducing distributed processing and data bases. The time has now come to ask the specific question "What are the Navy requirements?"

The Navy's informational requirements are basically divisible into two major areas, each radically different from the other. On the one hand there are the problem categories that the Navy has in common with the civilian world; these include payroll, inventory control, record keeping, maintenance, planning and programming, and so on. Problems of this kind are primarily of the non-real time variety, and can be dealt with by utilizing off-line, big batch type computers with cost effectiveness being a major consideration. On the other hand there is a separate set of problem categories which are almost unknown in the civilian world and which are created by the fact that the Navy must be ready to fight--to respond or to move instantly. The solution of these problems requires a completely different set of capabilities: tactical on-line, real time information processing in which reliability and ruggedness, with redundancy in the event of component loss, are far more important considerations than cost effectiveness. There is, between these two major areas, an almost total dichotomy of perspectives. Not only are the information requirements of, for example, a Navy pilot and a comptroller so different that they seldom, if ever, would have any common interest in information, but they are even further separated one from the other by the different sets of circumstances under which information must come to, and emanate from, them.

Let us look briefly at the basic requirements of the tactical Navy, using as a point of departure the Navy Tactical Data System (NTDS).[8] First of all, single ship capability is required: each ship must be self-sufficient. Secondly, however, each combat entity must be able to communicate with every other; constant liaison is required. Hence all systems must be compatible. Thirdly, because speed is so essential, the exchange of information must occur almost instantaneously, so that the human operator can make a decision in time. Thus, information must be exchanged over high speed data links, with computers themselves doing the communicating.

All of the foregoing requirements for an effective modern command and control system recommend the employment of distributed data systems. As our bibliography (see Annex A) makes clear, there is no dearth of information concerning such systems. Yet, although there exists in various parts of the Navy a certain amount of distributed processing capability, there is not much system to this decentralization. The current state of distributive processing and distributed data bases in the Navy can in large measure be attributed to problem solving on a localized, single problem basis. Consequently, custom designed information systems incompatible in both hardware and software with other systems abound. This problem is not confined to information processing only; in actuality, the total ship system integration problem is becoming more difficult. Difficulty in integration of systems is a measure of the difficulty of implementing an overall design philosophy. When a new weapon system or ship program is funded by Congress, with the result that a new system procurement office is formed, yet another custom-designed, incompatible information processing system is likely to be added to the Navy. It becomes apparent when looking at the existing diverse weapons systems that the question of distributed processing applications to Navy strategic and tactical requirements must be tackled from a more fundamental basis than system conversion. This shift of fundamental basis would be to increase emphasis on analysis of Navy strategic and tactical requirements in a functional frame of reference. Various functions and activities necessary to fulfil the Navy's missions and objectives under various modes of operation must be studied and specified. In order to accomplish such an undertaking for each proposed new platform or weapons system, a common framework must first be established under which such an analysis can proceed. Navy instructions for embedded computer software design and development provide scant "how to" help in this area, in our opinion. This statement is supported by a review of the list of pertinent Department of Defense instructions included as Annex B to this paper: "U.S. Navy Computer Software Management in Weapons System Acquisition: A Selected Bibliography."

B. Functional Frame of Reference

In dealing with the strategic, tactical and business requirements for viable information systems in the Navy, whether one is utilizing a centralized, decentralized or hybrid approach to system design, it is necessary to create some problem-solving structure. This structure can be called a "functional frame of reference."

The Navy is a hierarchically-structured organization with a chain of command for control in dealing or coping with the various modes of Navy operation (wartime, peacetime, natural disaster, etc.). It is an organization changing with time and world situations but which must maintain firm continuous control of all operations. Chain of command survival, is dependent upon the hierarchical character of unit organization. Information processing system designers contend that they are not concerned with changing the structure, but with adopting new information technology to serve the approved organizational structure. If distributed processing and data bases are implemented, they must be supportive of organizational functions. But the order in which design decisions are made becomes important. Is the organizational structure fixed, and functional improvements made, or are functional improvements nominated with resulting organization structure changes? Centralized computers have affected Navy organization functions and so will DDB.

The Navy organizational mission structure is shown in Figure IV-1. Navy policy directives are boundary setting in nature in that they define most often the restrictions or constraints imposed on decision-making. This is contrasted with other policy methods which may dictate the day-by-day operating decisions. Navy policy guidance permits a great deal of freedom for the decision maker. Missions are set within the overall Navy policy constraints and result in specific objectives. Missions and objectives do not, however, indicate action, but, instead specify the desired results. Functions and activities, on the other hand, are action related and are performed, hopefully, in the attainment of the desired results (objectives, missions). It is interesting to note that this environment encourages freedom to convert information into action based upon one's own interpretation of the situation. This probably accounts for the diversity of information processing systems in the Navy. Each manager is free to select and call for the information determined to be essential or important, set forth in formats designed to suit his or her particular functions and activities within existing policy guidance.

Figure IV-2 illustrates the decision-action environment. Information activities, either automated or manual, support the decision function. The decision function in itself could be looked at as an information conversion process in which inputs are converted to actions. One of the important inputs is experience. Experience is gained through feedback either formal or informal based on the results of actions taken in meeting objectives.

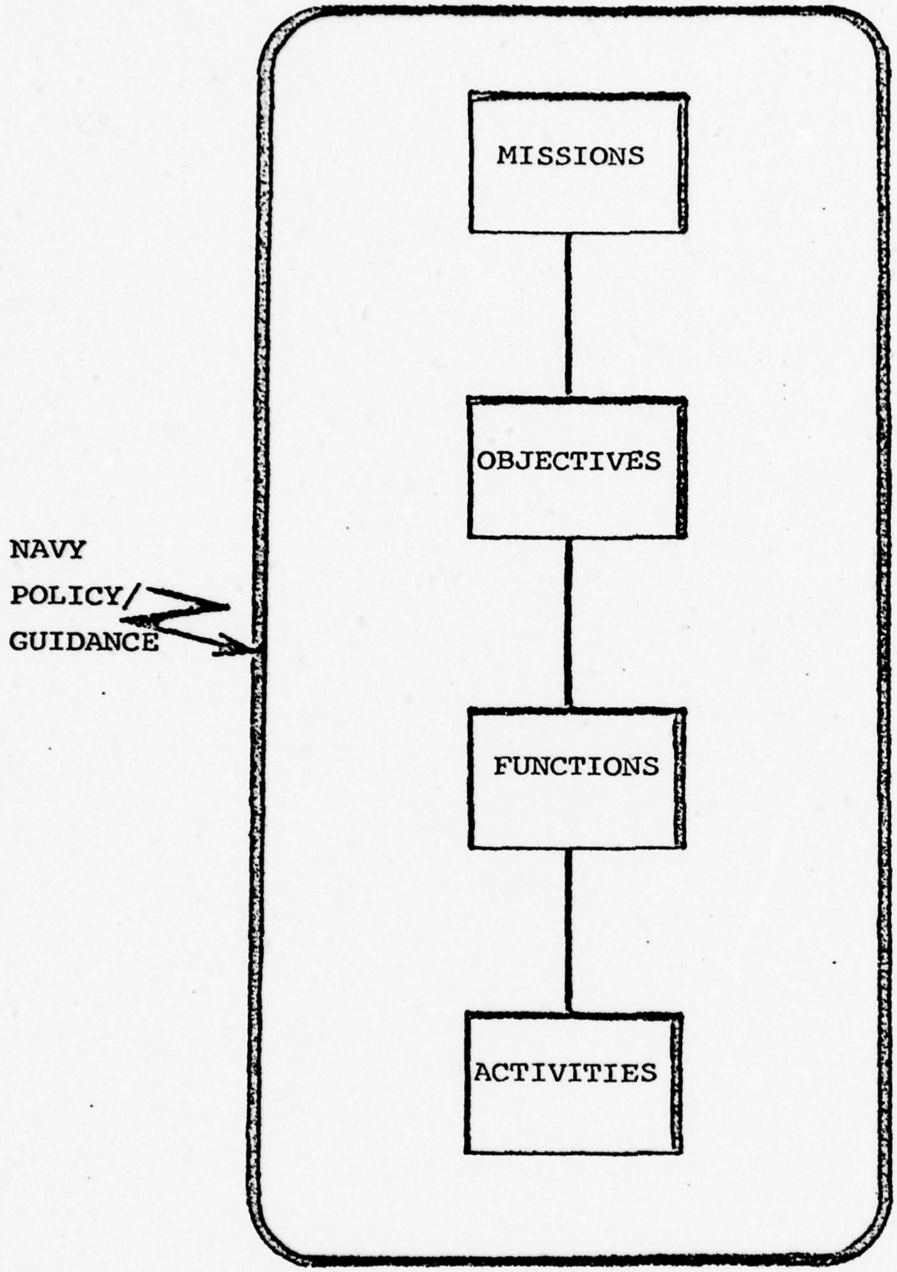

Figure IV-1: HIERARCHY OF NAVY ORGANIZATION MISSION STRUCTURE

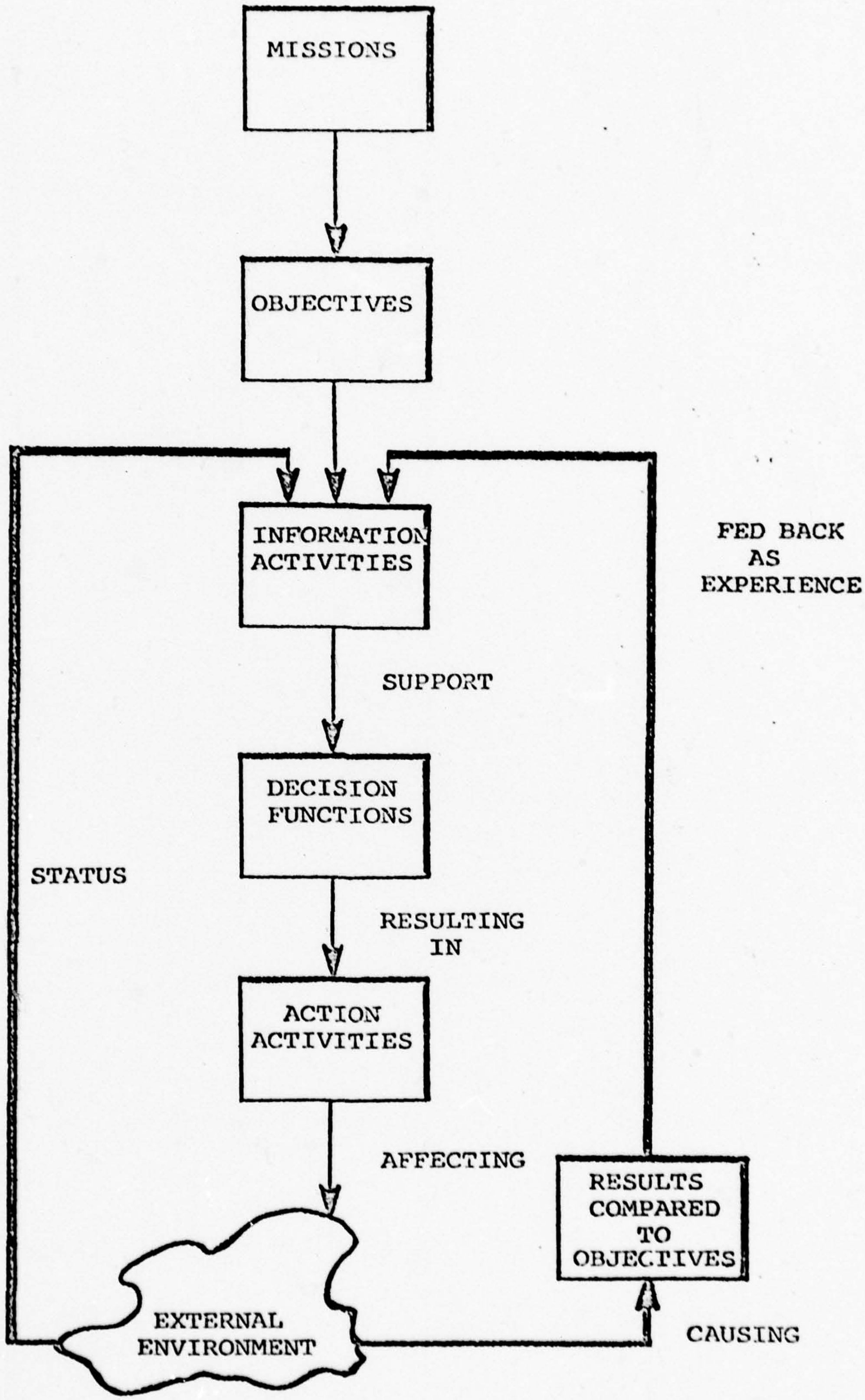

Figure IV-2: DECISION-ACTION ENVIRONMENT PROCESS

This representation of the decision-action environment is ideal. The fact of the matter is that delays and/or distortions of information occur throughout this process. The result is that incomplete information leads to decisions which create actual results which often differ from the anticipated result. This leads to instability and uncertainty. Managers often look to automation for the solution but the conversion from manual to automated information processing may not solve this problem. It may amplify it. Likewise, going to distributed processing without a proper requirements analysis could amplify existing information problems.

A starting point would be to look at the organizational levels in the Navy, including both combat and combat support commands, from a functional interface viewpoint and define functions which are generically suitable. These functions, which can be broadly categorized as internal to a given platform, intra-platform, and external (extra-Navy), can be examined for each platform, system, and subordinate elements in various situations as shown in Figure IV-3.

Figure IV-4 shows an example of information activities as related to functions. In this figure, various information activities are listed which represent a general categorization of subjects which must be addressed in any information processing requirements analysis. The figure does not attempt to show the interactions between decision functions and across intra, inter and external functions categories. It should be noted, however, that they do exist and are often complex. One can extend this general concept through all functions, from budgeting through deployment of weapons. We see that, while it is a relatively simple concept, consistent with existing instructions, its advocacy implementation and continued sponsorship in light of the present heterogeneous Navy information environment is clearly problematical.

C. Data Base Management Control

Sizeable though the task may be, it is apparent to us that Navy management must begin to discuss, delineate, and design specific mechanisms of data base management control. The preceding sections of this paper serve to identify the basic issues that Navy management might consider in its decision to employ distributed data base technology. We have also indicated how a manager might move from a localized single problem solution approach (incremental model) to a functional framework. All of these issues become just interesting sidelights to daily management decisions unless they can be shown to serve management objectives.

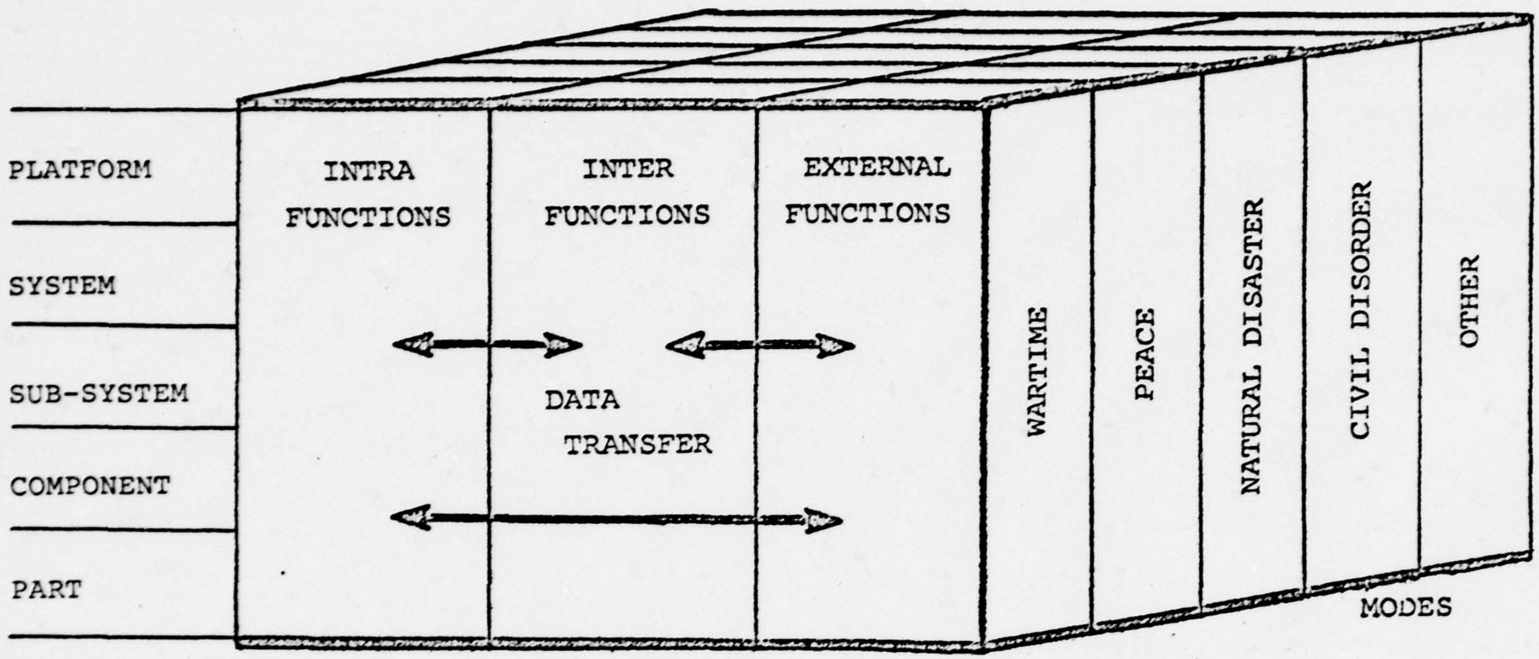

Figure IV-3: FUNCTIONAL MATRIX OF A NAVY ORGANIZATION

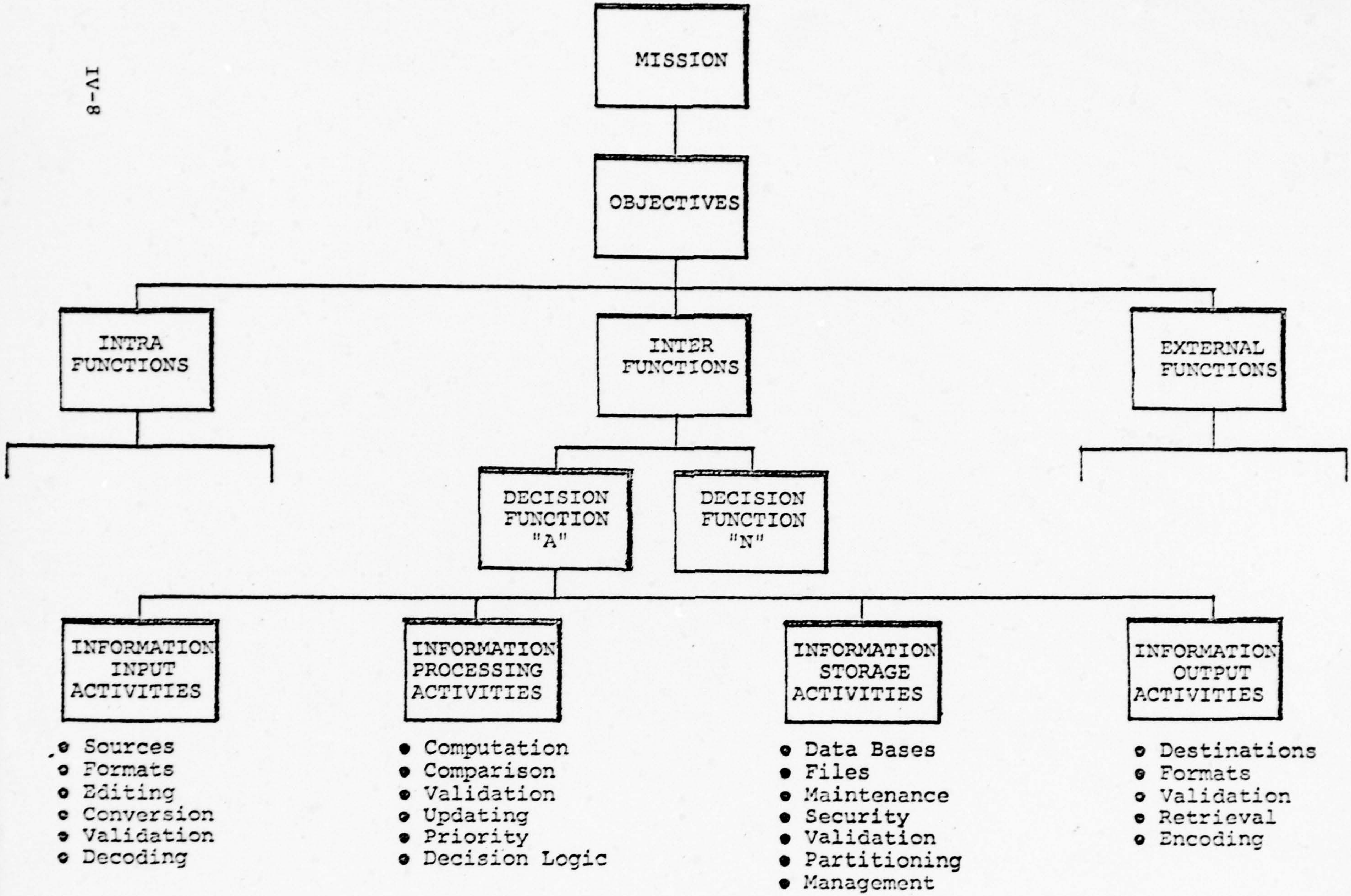

Figure IV-4: INFORMATION TOPOLOGY

DSC consultants believe that the management objective of control is essential. We have conceptualized above five general types of control factors. We repeat them as follows:

- Technological
- Structural
- Resource
- Personnel
- Performance

It is interesting to note that distributed data base technology emphasizes the decentralization of computer elements. Consequently technological variety is generated. Furthermore, resource variety may be increased if the demands for input of information is increased and/or output of information is increased because of the decentralization. However, in other control areas, such as personnel (and management in particular), a more centralized degree of control (with less variety) is probably indicated. Hence, there are variations in degree of control across the control spectrum.

How can we arrive at a determination of the optimum degree of centralization or decentralization in each Navy functional area across Navy objectives within various mission areas? Is each so different that each is considered unique? Are there no similarities of activities within functions? If an incremental decision-making approach (localized single problem solution approach) is used, then a manager might keep experimenting with coping strategies until a satisfactory solution is found by design or chance. This minimizes efficiency. Also effectiveness (compatibility and congruence with organizational objectives) may be threatened if a "solution" appears to be initially satisfactory but over time becomes incompatible with stated operational objectives. Data Solution consultants believe that the amount of time and energy invested in the incremental decision-making style is usually greater than the benefits accrued.

That is why we advocate a more systematic problem solving approach based on functional analysis and mission/objective requirements. Navy managers can look at the functional requirements and see what mix of control strategies (technology, structural, resource, personnel and/or performance) optimizes efficiency and effectiveness. Furthermore, they must begin to discuss and share ideas as to how the decision factors (situation, function, time frame, organization objectives and personel intent) affect these control strategies.

Another reason to employ this concept of control strategies is the need to manage organizational variety. W. Ross Ashby in Design for a Brain 9/ first postulated and described the Law of Requisite Variety. Stafford Beer discusses the concept further in Brain of the Firm and states that "control can be obtained only if the variety of the controller is at least as great as the variety of the situation to be controlled." 10/ Specifically, variety is "the total number of possible states of system or of an element of a system." 11/ How is this relevant to our preceding discussion of distributed data base technology?

As we have previously noted, distributed data base technology promotes variety generation as an explicit objective. Incremental decision making may allow variety generation to outstrip organizational control. Thus a manager is bound to an inefficient or ineffective strategy without recourse to improvement. Consequently the managers might back themselves into a no win situation. However a systematic functional analysis tied to the concept of control strategies would allow a manager to see the full range of options and their ensuing advantages and disadvantages. Rational decision making then becomes closer to being a reality. It is this sort of perspective that managers in the middle level of the Navy's data processing environment must take. It is imperative that their tasks and the skills that they bring to the tasks be well defined and well selected because these managers must manage variety, not only within the administrative and tactical levels but also between them. In our view, the concept of requisite variety presupposes an extensive training and skill development plan. We will cite the need for such a plan, among others, in the Solution Strategy section that concludes this report.

8/ For a further elaboration on this discussion, see Captain J. F. Jenista, "Navy Command and Control," in Prokop, Ed., op. cit., pp. 130-135.

9/ Ashby, W. Ross, "Design for a Brain," Chapman and Hall, 1952.

10/ Beer, Stafford, "Brain of the Firm," Herder and Herder, 1972, p. 53.

11/ Beer, Stafford, op. cit., p. 307.

V. SOLUTION STRATEGY

The first step in our proposed solution strategy is to adopt a methodology to examine functions, dissect them into activities, identify the information processing requirements, and reassemble the activities into function requirements, thereby synthesizing the organizational information requirements. This could initially begin with a prescribed procedure as follows:

1. Identify for each organization its essential functions.

2. Examine each decision function in terms of information required in order for activities to be satisfactorily performed.

3. Examine each activity in terms of information input, output, storage and processing related to time.

4. Identify activity to activity transfer of data.

5. Reassemble the activities into functions which should identify the information requirements of the functions.

6. Regroup the function by generic type (Intra, Inter, or External) to establish the information interfaces of the command and the requirements of organization for information technology.

This procedure could be conducted for each organization and any conflicts resolved by cooperative problem solving among the organizations (e.g., shift a function to another command; design a compatible interface; provide access by one command of another command data base; etc.).

A. Distributed Data Base Network Alternatives

Once the organizational information requirements have been determined and the appropriate degree of decentralization determined, the next step will be to look at the distributed data base network alternatives. Networks are the key to the interconnection of distributed processing elements or nodes. A network system can be designed in several different ways, none of which is absolute. A private network, that is the communication channels used by one specific user, probably will reflect the structure of the organization. A distributed network can be defined as "when there are many users sharing several application programs - and the users and the programs are not located in the same place--.[12] As can be seen this

definition also applies to the term of distributed processing, so both terms do relate to the same concept.

A ring network (Figure V-1) consists of several nodes, with no central control, linked to a communication channel. Each node contains a list of processing capabilities, some of which can reside in one or more nodes. The user at one node only addresses a process named in a message which travels along the bus until that particular process is found; the user does not have to know which of the nodes perform the application. This structure is considered by many to be a truly decentralized process.

The star configuration (Figure V-2) involves a central processor connected to each of the nodes. There can be some data base distribution as well as processing capabilities at each of the nodes, but all communication between nodes is done through the central site. Here, more rigid control of priority and function transfer is possible.

These are two typical network configurations. Other alternatives can be selected or devised.

One advantage for the user of distributed systems is that there is not one software structure to which users of the system must adhere. However, this doesn't mean that nodes or users are completely autonomous. Each node must be compatible with other nodes in terms of transfer of data or processing functions in support of other nodes in the network. A certain degree of centralized control must be present if the organization is to maintain any control over its goals and objectives. This can be accomplished by means of an orderly analysis of information requirements looking towards an acceptable overall and local orchestration method.

In order to effectively tackle the solution strategy we recommend for distributed data bases and processing, it will be necessary to bring key Navy management personnel together with general systems specialists. This assemblage must work under a common taxonomy of problem definition and solution. Hardware, software, and data base structure should not be permitted to govern the problem definition exercises but should only be looked upon as tools available for solving information problems.

B. Training and Skill Development Conversion Plan

A third step in the solution strategy will be to draw up an extensive training and skill development conversion plan to cover the elements of the solution that has been designed. This training will cover hardware, software, data base structure, and other aspects of the system for the various categories of specialists. The design of these training courses will be relatively simple once the more difficult second step of solution strategy has been worked out. As a matter of fact, it will not be necessary to design all of the necessary training courses from scratch. Courses are already in existence at many institutions of higher learning, as well as at certain of the service schools such as the Navy "A" and "B" Schools, The Defense Systems Management College, Program Management Course, The Department of Defense Computer Institute and the Navy Post-Graduate School Software Engineering Course Series (sponsored by NAVELEX and the Naval Research Laboratory). These schools and courses can fill, in whole or in part some of the training requirements we envisage. A review in depth of currently available courses could serve as a point of departure for the completion of a training matrix along the lines of the display in Figure V-3, with the different categories of training personnel shown along the top of the matrix and the course subject matter shown down the left-hand side. Currently available courses would fill some of the boxes in the matrix; where boxes then remain blank, consideration should be given to the development of new courses following a prioritized training development plan.

The approach described above is definitely feasible. Its implementation will require primarily the dedication of the time of those key Navy management personnel and general systems consultants who, acting in concert, are essential to its realization.

12/ Ruger, Charles H., "Analyzing Distributed Networks," Data Communications, Vol. 6., No. 8 (August 1977).

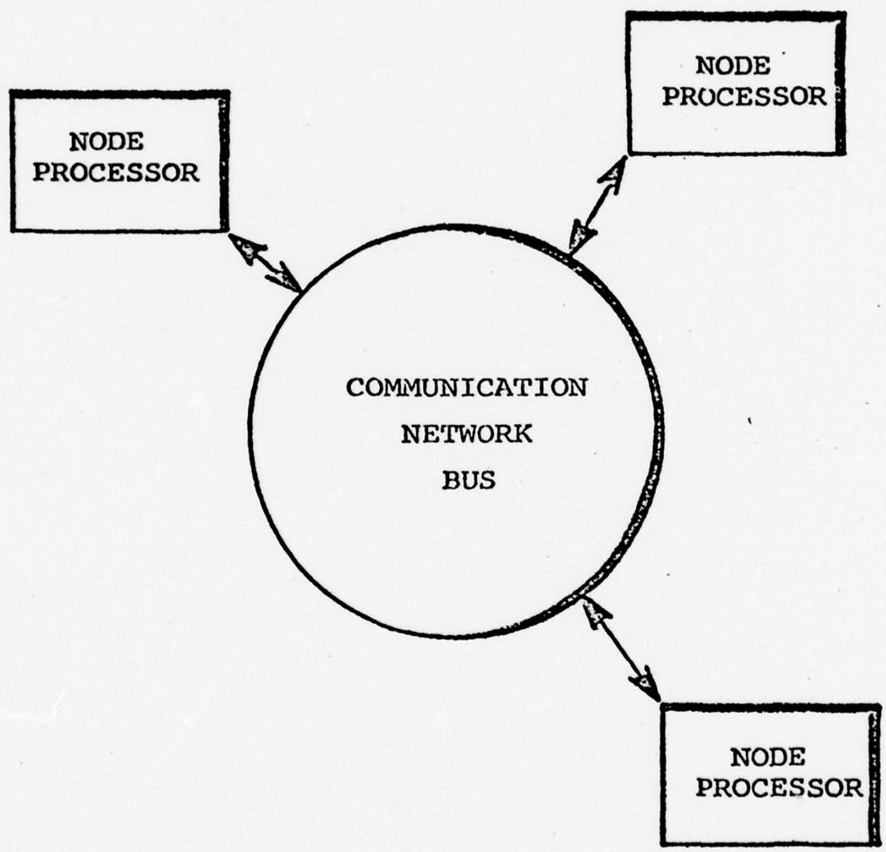

Figure V-1: RING NETWORK

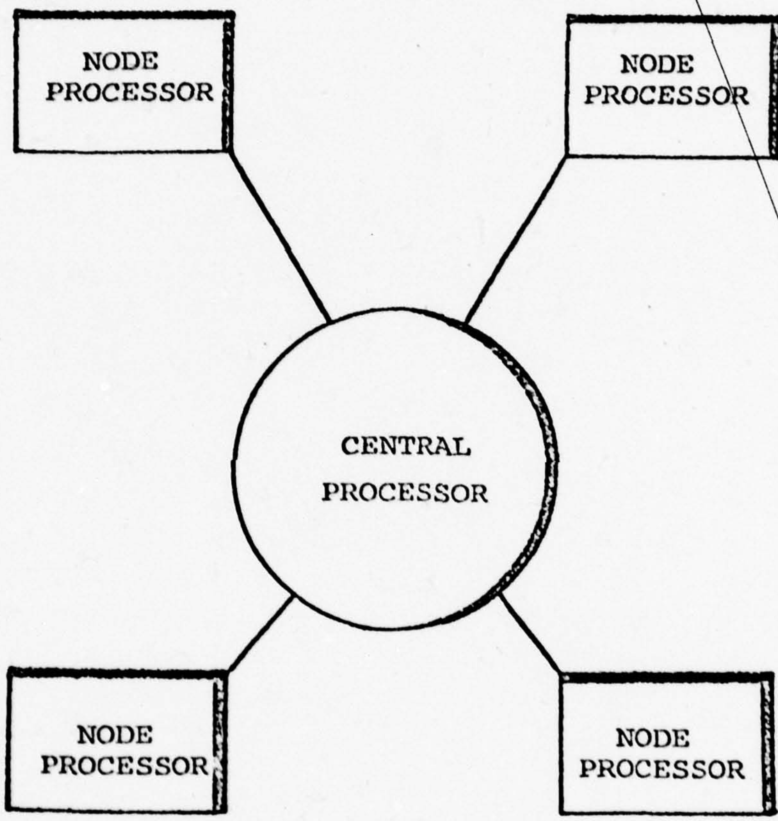

Figure V-2: STAR NETWORK

	SENIOR MANAGEMENT	SYSTEMS ANALYSTS	PROGRAMMERS	COMPUTER OPERATORS
PROBLEM SOLVING TECHNIQUES				
CONCEPTS OF DATA PROCESSING				
DISTRIBUTIVE DATA BASES				
COMPUTER HARDWARE				
OPERATING SYSTEMS				

FIGURE V-3: TRAINING MATRIX

ANNEX A

INDEX OF DISTRIBUTED PROCESSING TECHNOLOGY AND SELECTED REFERENCES

I. INDEX OF DISTRIBUTED PROCESSING TECHNOLOGY

This selected bibliography is grouped into three main general areas developed by Data Solutions for convenience as shown in Figure A-1. The first category, "Determining Factors," answers this question: What is DDP?; What is the logic behind DDP?. The second category, "Configuration," examines the dynamics of distributed data processing systems, through articles and papers describing an actual model or describing special equipment to do a certain job. This is the largest section and the most complex, and in no way it represents a true relationship of subjects. That has been the biggest problem in assembling this classification, since all sections and subdivisions are part of the whole picture.

The last category, "Applications," is a compilation of articles that describe how some organizations have implemented some forms of DDP.

Many of the articles and papers touch on more than one of these categories, so a list of the most relevant references from the selected bibliography has been listed under each section of the classification scheme. The last category does not have such a list since it would refer to all the references in the bibliography under that same heading.

A. Determining Factors

This category presents the literature of a descriptive nature on the subject of DDP and gives an insight to the current trends of thought on the present state of the art and what would be likely to develop in the future. This section is subdivided into three parts: Definition, Adaptation and Security and further subdivided as shown in Figure A-2.

A.1. Definitions

The following references represent comprehensive material that defines and describes various grades of distributed data processing, including definitions of a network, date base, minicomputer.

- "Distributed Processing/Data Communication", Fortune, March 1977.
- "Distributed Data Systems", EDP Analyzer, June, 1976.
- Down, P. J. and Taylor, F. E., "Why Distributed Computing?"

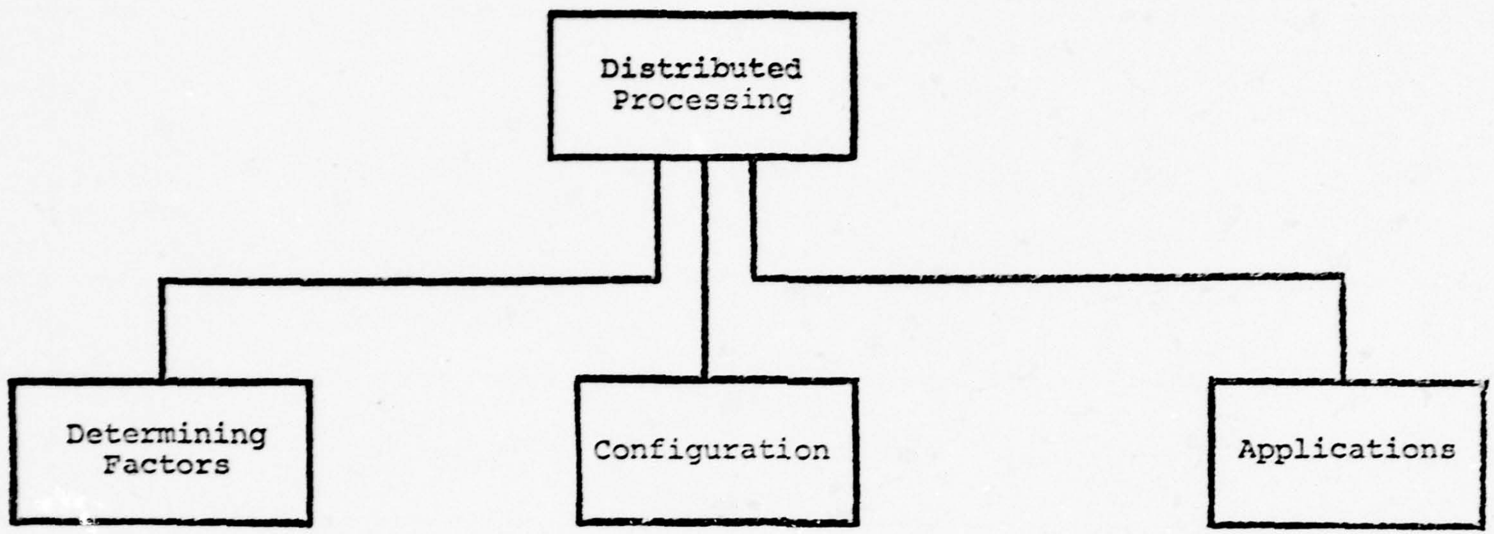
Distributed Processing
Determining Factors
Configuration
Applications

Figure A-1

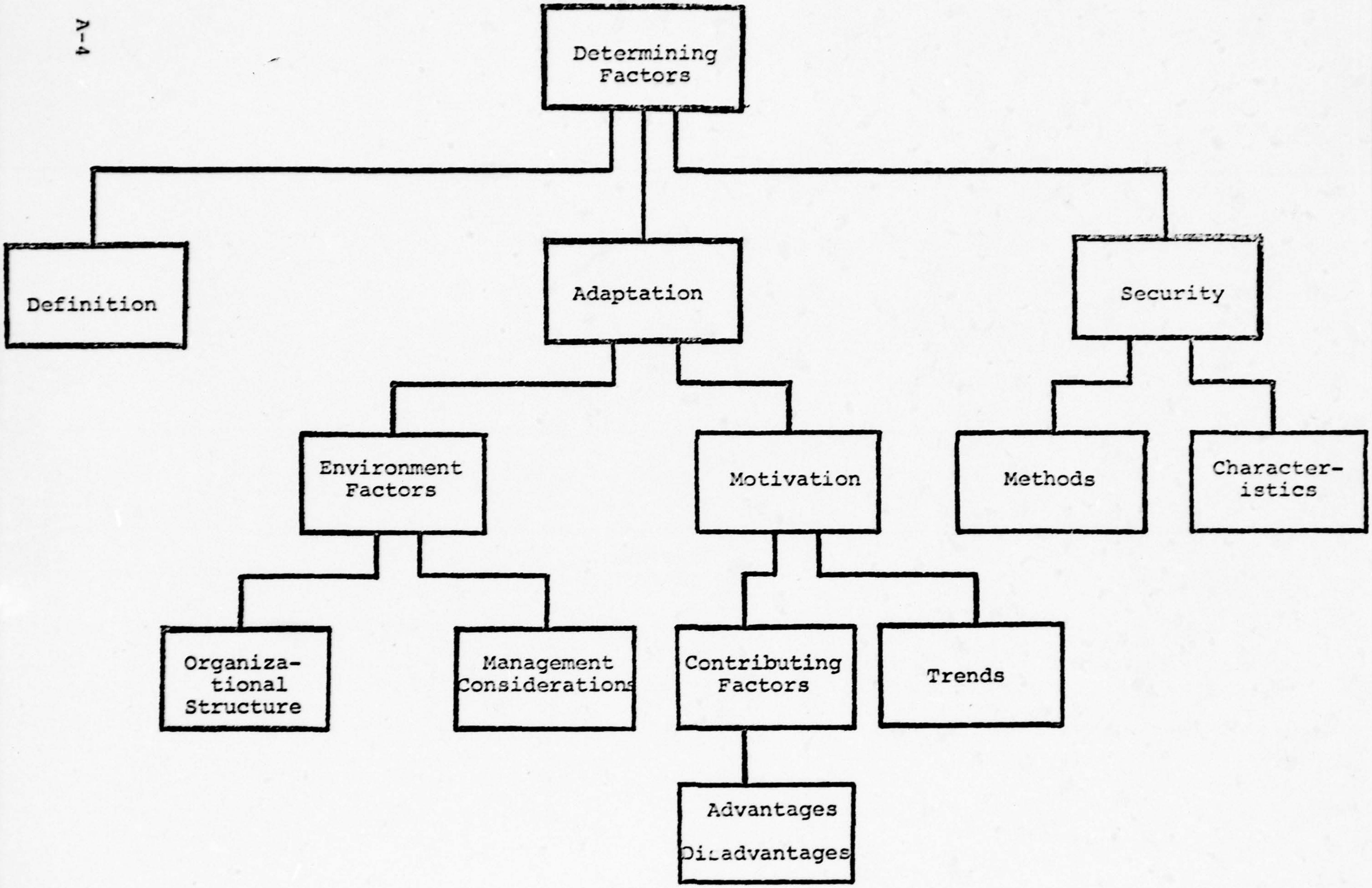
Determining Factors
Definition
Adaptation
Security
Environment Factors
Motivation
Methods
Character-istics
Organiza-tional Structure
Management Considerations
Contributing Factors
Trends
Advantages
Disadvantages

Figure A-2

- Enslow, Dr. P. H., "What Does 'Distributed Processing' Mean?".

- Lecht, Charles P., "The Waves of Change", Chapter 6.

- Farber, David J., "Distributed Data Bases - An Exploration".

- "Network Structures for Distributed Systems", EDP Analyzer, July 1976.

- Hansen, John R., "The Shape of Things to Come".

A.2. Adaptation

This section deals with the variety of arguments and different opinions of the people in the industry in favor of centralized systems and of distributed systems. It gives an idea of what are the major advantages and disadvantages of DDP. Also, it evaluates the impact that distribution would have upon the structure and environment of an organization and its management personnel. This section is further divided into two parts.

A.2.1. Environment Factors

The articles here focus on the managerial and organizational structure considerations that a company studying the feasability of a DDP system should evaluate.

- Champine, G. A., "Six Approaches to Distributed Data Bases".

- Bielec, John A., "Managing the Computer Non-center of the Future".

- "Centralization Backs Distributed Users", Computer World, May 9, 1977, Page 37.

- "Consider Future Applications, Measurable Productivity", Minicomputer News, July 14, 1977, Page 3.

- "Distributed Data Systems", EDP Analyzer, June 1976.

- Hannan, J. and Fried, L., "Should You Decentralize?".

- Keider, Stephen P., "Once Again - Centralize or Decentralize'.

- Kelley, Neil D., "Distributed Data Processing: Can You Afford a Disaster?".

- LaVoie, Paul, "Distributed Computing, Systematically".

- "New Trends in Data Processing", Dunn's Review, July 1977.

- Patrick, Robert L., "Decentralizing Hardware and Dispersing Responsibility".

- Poppel, Harvey L., "Distributed Processing Seen Lacking Understanding".

- Weber, Richard, "Decentralized Processing Has Advantages, Drawbacks".

- Feiderman, Lawrence, "It's a Small World".

A.2.2. Motivation

These articles refer to the contributing factors for distributed processing. They give an idea of what are the major advantages and disadvantages of DDP, and the current and future trends.

- "Distributed Data Systems", EDP Analyzer.

- Hannan, J., "Should You Decentralize?".

- "The Rationale For Distributed Systems", Infotech.

- Joseph, Earl C., "Distributed Processing Architecture - Past, Present and Future Trends", Infotech.

- Lecht, Charles P., "The Waves of Change" Chapter 6.

- Luke, John W., "Unraveling the Confusion of Distributed DP".

- Spiro, Kornel, "Computer Systems of the Future".

- Smith, Dr. Walton E., "Centralization vs. Decentralization".

A.3. Security

The subject of security has been separated since it is one of the principal considerations when implementing DDP, and it is used both to attack and defend the concepts of centralization and distribution. This section is subdivided into two parts dealing with the concepts of integrity of data bases, retrievability and redundancy of the system. Also it examines the methods to prevent illegal access to the system.

A.3.1. Methods

Techniques that enhance security of the system.

- Becker, Hal B., "Network Security in Distributed Data Processing".
- Grubb, Dana S., "System Security".
- Held, Gilbert, "Locking Intruders Out of a Network".
- Karp, Harry R., "Security and Radio Links Head Up Research List".
- Down, P. J., "Why Distributed Computing?".
- Spiro, Kornel, "Computer Systems of the Future", Page 29.
- Yasaki, E. K., "It's a Question of Experience".

A.3.2. Charcteristics

Articles depicting the security characteristics of distributed networks, data bases and the aspects of communication failure and recovery.

- Farber, David J., "Distributed Data Bases - An Exploration".
- Farber, David J., "A Ring Network".
- Held, Gilbert, "How Communication Switches Multiply Network Options, Part 2: Improving Availability".
- Ruger, Charles H., "Eight Factors Aid Network Design and User Interface".

- de Smet, Joe, "'Pacuit' Switching Combines Two Techniques in One Network".

B. Configuration

This category examines different methods to accomplish a distributed data base and distributed network architectures as shown in Figure A-3. The major sub-headings are: System Structures; Small Business Systems; Network Operation and Communications. Articles describing the configuration of small business systems, minicomputers and microprocessors. Also there are many articles of a technical nature that give a description of the hardware components in a network, and the protocol techniques used in transmission of data. The last subdivision deals with articles on future expectations of data communications and the current services offered on the market today. This section is subdivided into four parts.

B.1. System Structures

This section deals with the problems of distributing data bases and networks, it is divided into these 2 categories.

B.1.1. Data Bases

This section examines articles that deal with some actual experiences and also theories of data base distribution.

- Champine, G. A., "Six Approaches to Distributed Data Bases".
- Maryanski, Fred J., "A Minicomputer Based Distributed Data Base System".
- Farber, David J., "Distributed Data Bases - An Exploration".
- "Distributed Data Systems", EDP Analyzer, June 1976.
- Severino, Elizabeth, "Databases and Distributed Processing".
- Foster, John D., "The Development of a Concept for Distributive Processing".

B.1.2. Network Structures

The network is an intrinsic part of any communication system and plays a very important role when "going distributed". This section examines the different designs of

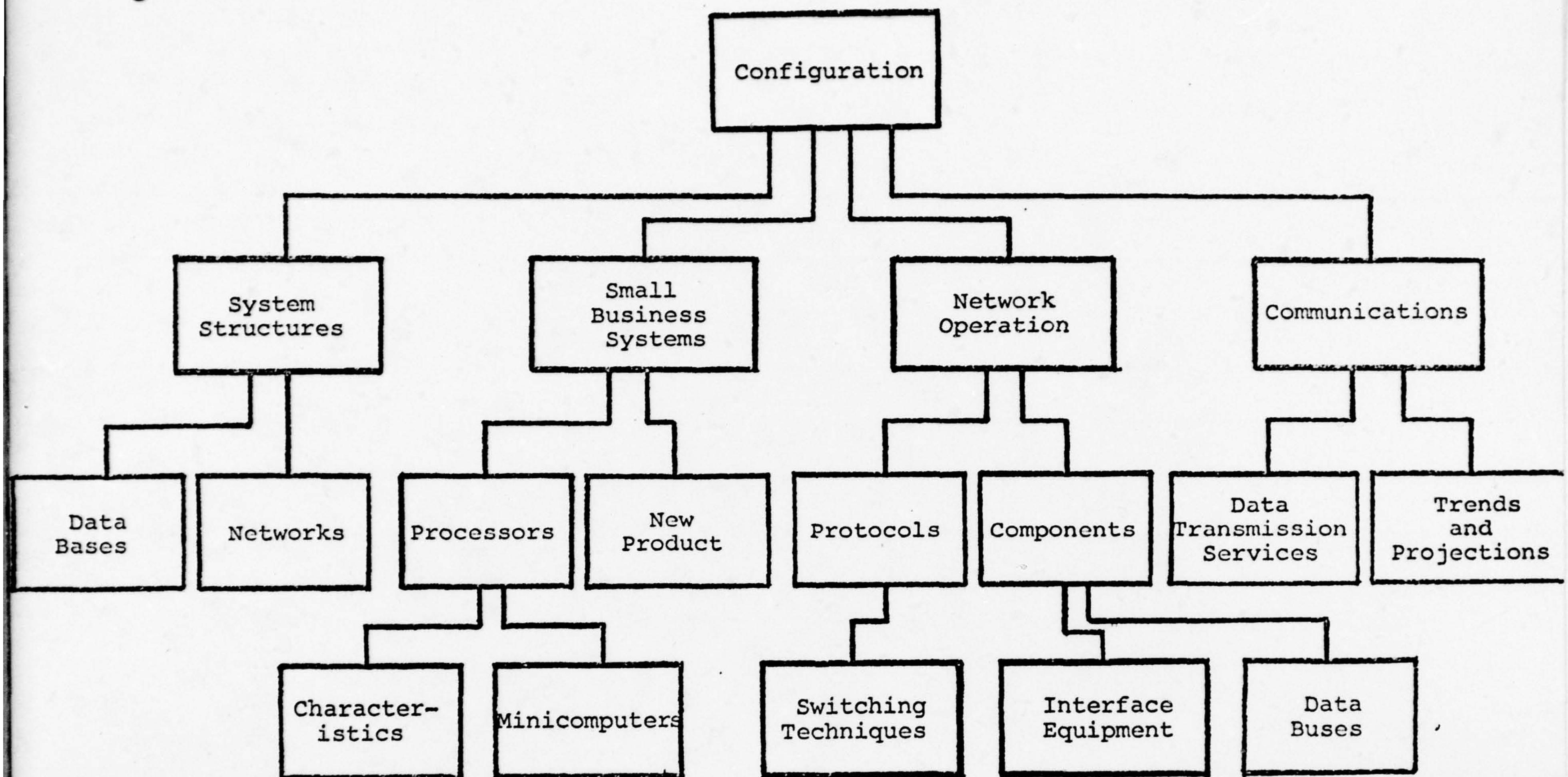
Configuration
System Structures
Small Business Systems
Network Operation
Communications
Data Bases
Networks
Processors
New Product
Protocols
Components
Data Transmission Services
Trends and Projections
Character-istics
Minicomputers
Switching Techniques
Interface Equipment
Data Buses

Figure A-3

network architecture from the centralized system to configurations in a distributed system.

- Lynch, Arthur, "Distributed Processing Solves Mainframe Problems".
- Ashenhurst, R. L., "A Hierarchical Network".
- Doll, Dixon R., "Relating Networks to Three Kinds of Distributed Functions".
- Blanc, Robert P., "Computer Networking".
- Farber, David J., "A Ring Network".
- Fraser, A. G., "A Virtual Channel Network".
- Karp, Harry R., "Networks: Future is Here but Designers Waiting".
- "Network Structure for Distributed Systems", EDP Analyzer.
- Ruger, Charles H., "Eight Factors Aid Network Design and User Interface".
- Wolf, Eric W., "An Advanced Computer Communication Network". (ARPA)
- Wulf, William, "A Local Network".

B.2 Small Business Systems

Under this heading, there are articles and papers that deal with the field of minicomputers, microprocessors, data entry systems, etc. This section is subdivided into three parts.

B.2.1. Characteristics

Articles of a general nature describing the direct relationship of the new technology (minicomputers) and DDP.

- Anderson, L. H., "Distributed Intelligence Microcomputer Systems (DIMS)".
- Feidelman, Lawrence, "Distributed Computing - It's a Small World".

- Reagan, Fonnie H., "The Big Promise of Small Business Systems".

- Klotz, William H., "Combining Data Entry With Dispersed DP".

B.2.2. Processors

These articles deal with the characteristics of minicomputers and microprocessors, some of their features and costs.

- Bowers, Dan M., "Minicomputers and Microcomputers".

- Hansen, John R., "The Shape of Things to Come".

- Bailey, S. J., "Put Memories in Control; Enhance Process Response".

- Yasaki, E. K., "The Mini: A Growing Alternative".

- Yasaki, E.K., "The Emerging Microcomputer".

B.2.3. New Products

This section contains articles that describe products offered by different vendors and manufacturers.

- Options Grow for Small Business, Distributed Users".

- Growth of Cobol: Signal of Trend to Distributed DP?".

- "MDS Offers Distributed Processing Systems".

- "Computer Starts Family of Large-Memory CRTs".

- "Four-Phase Word Processing System Ties 32 Stations".

- "DS/3000' Lets Users Process Data on Any HP 3000-II in Net".

B.3. Network Operation

A look into some of the equipment which forms part of a network, such as modems and concentrators, the data transfer channels and the different techniques used in protocol. This category is subdivided into two parts.

B.3.1. Protocol

An examination of switching techniques, packets, messages, circuits.

- Jenny, Christian J., "Distributed Processing Within an Integrated Circuit/Packet-Switching Node".
- "Network Structures for Distributed Systems", EDP Analyzer.
- Nichols, Patrick J., "General-Purpose Protocol Integrates Different Networks".
- Sharp, Duane E., "Combined Traffic Flows Quickly on Packet-Switched Network Systems".
- de Smet, Joe, "'Pacuit' Switching Combines Two Techniques in One Network".

B.3.2. Components

This section deals with the physical or hardware requirements that link nodes in a network. It is divided into two parts.

B.3.2.1. Interface Equipment

A brief incursion into the area of modems, multiplexens and concentrators.

- Greer, Curtis L., "Designing a Least-Cost Network With Split-Channel Modems".
- Held, Gilbert, "Sharing at the port: An economical Way to Reach the Host".
- Geld, Gilbert, "How Communication Switches Multiply Options, Part 2: Improving Availability".
- Nichols, Patrick J., "General-Purpose Protocol Integrates Different Networks".
- Ruger, Charles H., "Eight Factors Aid Network Design and User Interface".
- Lyon, David L., "Testing Modem Performance in Polled Operation".

- "Network-Control System Provides Modem Supervision for Monitoring, Diagnosis, Rerouting", Data Communications.

- Riviere, Charles J., "How Concentrators Can Be Message Switchers As Well".

C. Communications

C.1. Data Transmission Services

An overview of commercial network services available in the market and what the user can expect in the near future.

- "Data Networks", 1974 IEEE Intercon Technical Papers.

- Lecht, Charles P., "The Waves of Change", Chapter V.

- Piatowski, Thomas F., et. al., "Inside IBM's Systems Network Architecture".

- "SNA Survival Short, Expert Predicts", Computerworld, August 15, 1977, Page 23.

- Caswell, Stephen, "Satellite Business Systems: The Start of Something Big".

- "Communications Satellite Corp.", Financial World, March 1, 1977, Page 16.

- "The Domsat War Gets Tougher and Costlier", Dunn's Review, May 1977, Page 72.

- Uttal, Bro, "IBM Reaches for a Golden Future in the Heavens".

C.1.2. Data Buses

Technological descriptions of data buses, also called data highways, and the development of new lines of communications such as coaxial cable, filier optics, microwave.

- "Alternate Mode Outlined for High-Speed Transmission", Computerworld, June 13, 1977, Page 81.

- Andreiev, Nikita, "In Quest of a Common Data Bus".

- Andreiev, Nikita, "A Closer Look at Data Bus Systems".

- "Bankers Trust Pioneering With Fiber Optic Cable", Data Communications, August 1977, Page 16.

- Reese, Irving, "Fiber Optic Data Bus for Control - A Reality!".

C.2. Trends and Projections

These articles describe the future of communications and the need for standardization.

- Cerf, Vinton G., "The Future of Computer Communications".

- Faber, David and Baran, Paul, "The Convergence of Computing and Telecommunications Systems".

- Ferreira, Joseph and Nilles, Jack M., "Five-Year Planning for Data Communications.

- "Harold C. Folts, Government Engineer is working quietly, but firmly to push for interface standards", Data Communications, August 1977, Page 29.

D. <u>Applications</u>

This last category of the bibliography contains articles on commercial and government organizations which have implemented some form of distributed data processing on the financial sector as well as the technical side. The sub-headings under this classifications could take the form shown in Figure A-4.

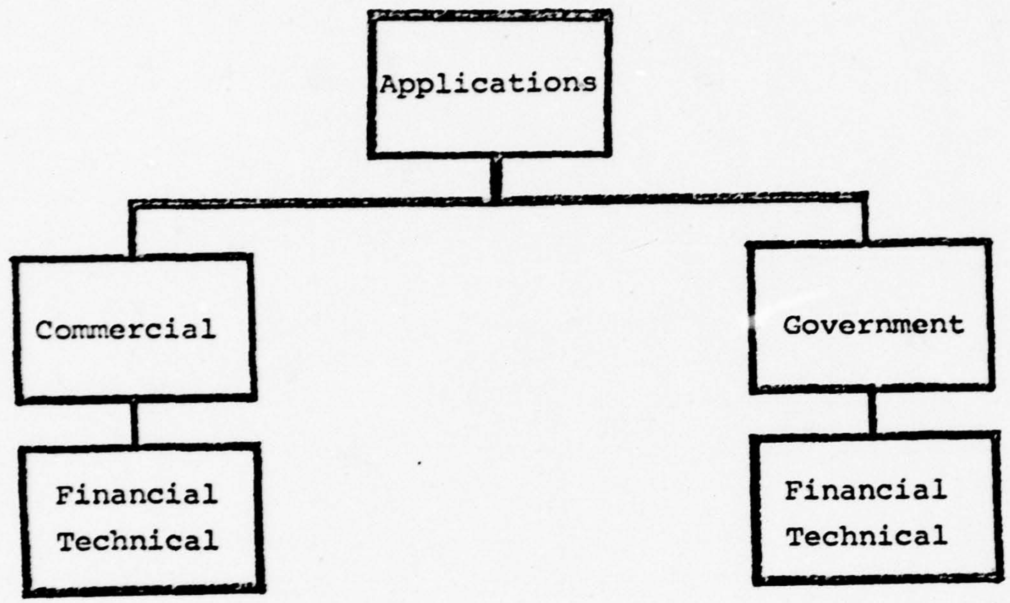
Applications
Commercial
Government
Financial
Technical
Financial
Technical

Figure A-4

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3. Bielec, John A. "Managing the Computer Non-center of the Future," Infosystems, May 1977, p. 70.

4. Bibliography for Distributed Processing Workshop, Brown University, Program in Computer Sciences, Providence, Rhode Island 02912, August 1976-August 1977.

5. Brown, G. A., "Letter to Editor," "Distributed System," Datamation, May 1977, p. 21.

6. "Centralized Backs Distributed Users," Computerworld, May 9, 1977, p. 37.

7. "Consider Future Applications, Measurable Productivity," Minicomputer News, July 14, 1977, p. 3.

8. "Consultant Views Distributed Processing as Cyclical," Computerworld, May 2, 1977, p. 54.

9. "DDP Observers Find Decentralization Not Just Passing Fad," Computerworld, July 11, 1977, p. 13.

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11. "Distributed DP Seen Turning Experts Into Policymakers," Computerworld, May 30, 1977, p. 7.

12. "Distributed DP to Erode Vendor Loyalty," Minicomputer News, July 14, 1977, p. 4.

13. "Distributed Processing/Data Communications," Fortune, Text prepared by International Data Corporation. Special Advertising Section appearing in the March 1977 issue.

14. "Distributed Systems Market Will Total $4.6 Billion by '81," Minicomputer News, June 2, 1977, p. 20.

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16. "Distributed Processing Not Commercial Reality," Computerworld, August 22, 1977, p. 15.

17. "Distributed Processing Viewed as Outgrowth of T/S," Computerworld, April 18, 1977, p. 36.

18. Dolotta, T.A., et. al., "A Study of Potential Limitations to Progress," Data Processing in 1980-1985, pp. 81-82.

19. Down, P. J., Taylor, F. E., Why Distributed Computing? NCC Publications, The National Computing Centre Limited, Oxford Road, Manchester M1 7ED, England.

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B. Configuration

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ANNEX B

SELECTED REFERENCES OF APPLICABLE
INSTRUCTIONS FOR COMPUTER UTILIZATION
IN U.S. NAVY WEAPON SYSTEM ACQUISITION

SELECTED REFERENCES OF APPLICABLE

INSTRUCTIONS FOR COMPUTER UTILIZATION

IN U.S. NAVY WEAPON SYSTEM ACQUISITION

I. DEPARTMENT OF DEFENSE

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* 2.	DOD DIRECTIVE 5000.2 18 January 1977	Major System Acquisition Process
3.	DOD DIRECTIVE 5000.3 19 January 1973	Test and Evaluation
4.	DOD DIRECTIVE 5000.4 13 June 1973	OSD Cost Analysis Improvement Group (CAIG)
5.	DOD 5000.8	Design to Cost
* 6.	DOD DIRECTIVE 5000.26	Defense Systems Acquisition Review Council (DSARC)
* 7.	DOD DIRECTIVE 5000.29 26 April 1976	Management of Computer Resources in Major Defense Systems
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* 9.	DOD 7000.1	Resource Management Systems of the DOD
*10.	DODINST 7000.2 10 June 1977	Performance Measurement for Selected Acquisition
11.	DODINST 7000.6 15 March 1971	Acquisition Management Systems Control
12.	DOD GUIDE	Life Cycle Costing Procurement
13.	DOD GUIDE	Case Book Life Cycle Costing

NOTE: PRINCIPAL SOURCES SUGGESTED BY ASTERISK (*)

14.	DOD GUIDE	Life Cycle Costing Guide for System Acquisitions
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*16.	SECDEF MEMO 18 January 1978	Mission Element Needs Statement
*17.	TADSTAND X 16 March 1976	Standard Tactical Digital System Software Quality Assurance Testing Criteria
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2.	SECNAVINST 4200.18B	Advanced Procurement Planning
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III. CHIEF OF NAVAL OPERATIONS (OPNAV)

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2.	OPNAVINST 3960.10 22 October 1975	Test and Evaluation
3.	OPNAVINST 4100.3A 11 June 1972	Department of the Navy ILS System
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6.	OPNAVINST 5000.42A 3 March 1976	Weapon Systems Selection and Planning
* 7.	OPNAVINST 5000.46 10 March 1976	DCP's, PM's, and NDCP's - Preparation and Processing

IV. NAVY MATERIAL COMMAND (NAVMAT)

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* 5.	NAVMATINST 4200.31A	Advanced Procurement Planning
6.	NAVMATINST 5000.19A 24 June 1974	Quarterly Project Status Reviews
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*12.	NAVMAT 09Y:JDC SER 304 5 November 1974	TADSTAND 3 (Revision 1) Standard Requirements for Inter-Digital Processor Interface Documentation
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V. NAVAL SEA SYSTEMS COMMAND (NAVSEA)

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VI. OTHER (OMB, PM-20)

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* 2.	PM 20-1 SER C12 4 March 1977	ASMD Program Plan